

**MOLDED PLASTIC HOT-FILL CONTAINER AND METHOD OF MANUFACTURE**

The present invention is directed to molded plastic containers that are particularly adapted for hot-fill applications, in which vacuum panels are provided on the container wall to flex inwardly and thereby absorb vacuum pressure as the contents of the container cool.

**Background and Summary of the Invention**

In so-called hot-fill packages, a container is filled with hot fluid product and capped while the fluid product is still hot. As the fluid product cools, a reduction in fluid volume creates a vacuum within the package - i.e., an internal pressure that is less than the surrounding atmospheric pressure. When the container is of molded plastic construction, the container wall tends to distort inwardly as the fluid cools. It has been proposed to provide vacuum panel areas on the container wall for controlling the areas of distortion under vacuum. These vacuum panels conventionally are placed in the body portion of the container over which a label subsequently is applied, causing the label undesirably to "crinkle" in a user's hand because of the absence of contact and adhesion entirely around the container wall. It is a general object of the present invention to provide a plastic container and a method of making such a container that are particularly well adapted for use in hot-fill applications, and/or in which vacuum panels are provided in the container wall in an area separate from the label application area, and/or in which the vacuum panels lend an ornamental appearance to the container as a whole, and/or in which the label application area is as large as that of a comparable glass container.

The present invention embodies a number of different aspects, which may be implemented separately from or more preferably in combination with each other.

A blow molded plastic hot-fill container in accordance with a first aspect of the invention includes at least one vacuum panel for inward flexure under vacuum after the container is hot-filled and capped. The vacuum panel is externally concave as viewed in cross section from a first direction and externally convex as viewed in cross section from a second direction orthogonal to the first direction. The at least one vacuum panel preferably is disposed in a sidewall of the container, which preferably is of generally uniform wall thickness, and preferably includes an array of vacuum panels angularly spaced around an axis of the container.

A blow-molded plastic hot-fill container in accordance with a second aspect of the invention includes a base for supporting the container, a body extending from the base, a dome extending from the body and a neck finish extending from the dome. The dome includes an array of vacuum panels, with each of the vacuum panels being externally concave as viewed in cross section from a first direction and externally convex as viewed in cross section from a second direction orthogonal to the first direction. In the preferred embodiment of the invention, the vacuum panels are externally concave as viewed in cross section laterally of the dome, and externally convex in cross section as viewed axially of the dome. The dome, including the array of vacuum panels, preferably is of generally uniform wall thickness, and the vacuum panels preferably have longitudinal axes at acute angles to the central axis of the container neck finish.

A blow-molded plastic hot-fill container in accordance with a third aspect of the invention includes a base for supporting the container, a body extending from the base, a dome extending from the body and a neck finish extending from the dome. The dome includes an array

of flexible resilient vacuum panels, with each of the vacuum panels being externally concave as viewed in cross section from a first direction and externally convex as viewed in cross section from a second direction orthogonal to the first direction. The dome, including the array of vacuum panels, preferably is of generally uniform wall thickness and circular in cross section. The body of the container is of cylindrical construction, and includes axially spaced lands for applying a label to the container. Thus, the label is applied to the generally cylindrical body of the container while the vacuum panels are disposed in the dome of the container, so that the label does not overlie the vacuum panels and does not "crinkle" when gripped by a user.

A fourth aspect of the present invention contemplates a method of blow molding a plastic container in accordance with any of the first, second and third aspects of the invention.

#### **Brief Description of the Drawings**

The invention, together with additional objects, features, advantages and aspects thereof, will be best understood from the following description, the appended claims and the accompanying drawings, in which:

FIG. 1 is an elevational view of a blow-molded plastic hot-fill container in accordance with one presently preferred embodiment of the invention;

FIG. 2 is a top plan view of the container illustrated in FIG. 1;

FIGS. 3-8 are fragmentary sectional views taken substantially along the respective lines 3-3 through 8-8 in FIG. 1; and

FIGS. 9 and 10 are elevational views of containers in accordance with respective modified embodiments of the invention.

### **Detailed Description of Preferred Embodiments**

FIGS. 1-2 illustrate a container 10 in accordance with one presently preferred embodiment of the invention. Container 10 includes a base 12 for supporting the container, and a body 14 extending upwardly from the base. A dome 16 extends upwardly from body 14, and a neck finish 18 extends upwardly from dome 16. In the illustrated embodiment of the invention, container 10 is generally circular in cross section, with base 12, body 14 and dome 16 being coaxial with the central axis of neck finish 18. (Directional words such as “upwardly” and “downwardly” are used by way of description and not limitation with respect to the upright orientation of the container shown in FIG. 1. Directional words such as “axially” and “radially” are employed by way of description and not limitation with respect to the central axis of the neck finish, which preferably is coaxial with the central axis of the container.) Neck finish 18 is generally cylindrical in geometry, and has one or more external attachment features, preferably external thread or thread segments 20, for attaching a closure to the container. Body 14 is generally cylindrical in construction, preferably having an external periphery that is recessed or stepped radially inwardly from the peripheries of base 12 and dome 16.

Dome 16 has an array of vacuum panels 30 circumferentially spaced from each other, preferably equidistantly spaced, around the circumference of dome 16. Vacuum panels 30 are flexible and resilient, and are separated from each other by a circumferentially spaced plurality of ribs 32. The external surfaces of ribs 32 lie on a common surface of revolution around the axis of neck finish 18, with vacuum panels 30 being recessed radially inwardly from this external surface of revolution. As best seen in FIG.1, each of the panels 30 has a longitudinal axis at an acute angle

to the central axis of neck finish 18, and ribs 32 are also angulated with respect to the central axis of the neck finish. Ribs 32 are identical to each other, as are vacuum panels 30. Ribs 32 join annular rings 34, 36 at the top and bottom of dome 16 to form a relatively rigid frame, within which panels 30 form relatively flexible resilient windows. Dome 16 is generally conical in the illustrated embodiment of the invention, and ribs 32 preferably are of uniform width. Vacuum panels 30 thus taper slightly in width from bottom to top.

As best seen in FIGS. 3-5, vacuum panels 30 are bowed radially inwardly - i.e., are concave from outside of the container - as viewed in lateral cross section - e.g., tangential cross section in a circular container. However, as best seen in FIGS. 6-8 vacuum panels 30 are bowed radially outwardly - i.e., are convex in cross section from outside of the container - as viewed in axial cross section. This vacuum panel geometry enhances the performance of the vacuum panels in absorbing vacuum forces on the container sidewall after filling the container with hot fluid, capping the container and allowing the container and fluid product to cool. That is, this vacuum panel geometry significantly increases vacuum performance in terms of volume reduction from inward movement of the vacuum panels. Inward flexure of panels 30 under vacuum is illustrated in phantom in FIGS. 3-8.

The container of the present invention preferably is blow molded from a preform, such as an extruded tubular preform or, more preferably, an injection or compression molded preform. The dome 16 of the container is of substantially uniform wall thickness. That is, the wall thickness of the dome 16, including both vacuum panels 30 and ribs 32, is of nominally uniform wall thickness, meaning that any thickness variations are due to manufacturing anomalies and/or differential stretching during blow molding. For example, with the tapering dome construction

illustrated in FIG. 1, the lower portion of the dome will expand slightly more than the upper portion of the dome during blow molding, so that the lower portion of the dome will have a slightly lesser wall thickness than the upper portion. In the same way, ribs 32 expand outwardly during blow molding slightly more than vacuum panels 30. However, as shown in FIGS. 3-8, the wall thickness of dome 16 is substantially uniform both axially and circumferentially in the dome.

FIG. 9 illustrates a modification 40 to the container of FIGS. 1-8, in which a pair of radially inwardly extending circumferential ribs 22, 24 extend around body 14 adjacent to dome 16 and base 12 respectively. Ribs 22, 24 thus form a pair of axially spaced external cylindrical lands 26, 28 for attachment of a label to body 14.

FIG. 10 illustrates a second alternative embodiment 42 of the invention. A waist 44 connects a container body 46 to a dome 48. An angularly spaced circumferential array of vacuum panels 50 are disposed around dome 48. Panels 50 are separated from each other by ribs 52. Vacuum panels 50 are externally concave in lateral cross section and externally convex in axial cross section, as in the embodiments of FIGS. 1-9. The outer surfaces of ribs 52 are on a common conical surface of revolution, and panels 50 are recessed radially inwardly from this surface of revolution. The longitudinal centerlines or axes of the panels are coplanar with the container axis, rather than at a lateral angle to the container axis as in the embodiments of FIGS. 1-9.

Container 10 may be of any suitable monolayer or multilayer plastic construction, such as polyester (e.g., polyethylene terephthalate (PET) or polyethylene terephthalate glycol (PETG) or polyethylene naphthalate (PEN)), or polyolefin (e.g., polypropylene (PP) or polyethylene (PE)).

There have thus been disclosed a hot-fill plastic container and a method of manufacture that fully satisfy all of the objects and aims previously set forth. The invention has been disclosed in conjunction with a presently preferred embodiment thereof, and a number of modifications and variations have been discussed. Other modifications and variations will readily suggest themselves to persons of ordinary skill in the art. For example, although five vacuum panels are illustrated in the preferred embodiment, a greater or lesser number of vacuum panels could be employed, such as six or four. The container dome could be other than tapering, such as cylindrical, preferably being generally round in cross section perpendicular to the container axis. The vacuum panels could be positioned in the body portion or the base portion of the container. For example, the container could be a rectangular container, and the concave/convex vacuum panels in accordance with the broadest aspects of the present invention could be disposed on the short walls of the rectangular body portion of the container. The invention is intended to embrace all such modifications and variations that fall within the spirit and broad scope of the appended claims.